Fouling Increases Stack Temperatures

The extent to which boiler tubes are fouled can be estimated from an increase in stack temperature relative to a "clean operation" or baseline condition. The loss in boiler efficiency is approximately 1% for each 40°F increase in stack gas temperature.

Clean Boiler Fire-side Heat Transfer Surfaces

Soot buildup on the fireside of the boiler heat transfer surfaces inhibits heat transfer. When less heat is transferred to the boiler water, more heat remains in the flue gases and is rejected up the stack. As shown in the table, a layer of soot only 1/32nd of an inch in thickness reduces boiler efficiency by an estimated 2.5%.

Boiler Efficiency Reduction Due to Soot Deposits*

Boiler Efficiency Reduction		
Soot Layer Thickness, inches		
1/32	1/16	1/8
2.5%	4.5%	8.5%

* Extracted from the Application Note – *Energy Efficient Operations and Maintenance Strategies for Industrial Gas Boilers*, Pacific Gas and Electric Company, May 1997.

Fuel oil combustion deposits predominately consist of soft black soot. For small fire-tube boilers, these deposits are easily removed by manual brushing. Lower grade fuel oils (residual or No. 6 oil) cause more serious gas-side deposits. Solid fuels such as coal and wood wastes produce deposits that contain ash-based slag. If not removed immediately, these deposits can become sintered or melt into a difficult to remove glass-like insulating layer. Large water-tube boiler deposits can be removed with a blast of high-pressure steam. With low-quality fuels, soot blowing may be necessary as frequently as once per shift.

Example

Consider a boiler that consumes 450,000 million Btu (MBtu) of fuel during 8000 hours of annual operation at its rated capacity of 45,000 pounds per hour (lbs/hr) of 150 pounds-per-square-inch-gauge (psig) steam. The boiler has an efficiency of 82% (E_1) with no soot present. With energy priced at $3.00/MBtu, an average soot buildup of 1/16th inch reduces boiler efficiency by 4.5% to 77.5% (E_2) and increases annual operating costs by:

$$\text{Annual Operating Cost Increase} = 450{,}000\ \text{MBtu/yr.} \times (E_1/E_2 - 1) \times \$3.00/\text{MBtu}$$
$$= \$78{,}387$$

Suggested Actions

Reduce fuel costs by periodically cleaning boiler tube heat transfer surfaces. Common causes of fouling include low air-to-fuel ratios, improper fuel preparation, or a mal-functioning burner. Fireside fouling is not likely when natural gas fuel is used with a properly functioning burner. But, natural gas burning fire-tube boilers should have their tubes inspected at least once per year, with tubes cleaned or "punched" as required.

For additional information on industrial energy efficiency measures, contact the OIT Clearinghouse at (800) 862-2086.

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The Office of Industrial Technologies (OIT), through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution prevention technologies for industrial applications. OIT is part of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

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Aluminum	Forest Products	Metal Casting	Petroleum	

To help industries begin to save energy, reduce costs, and cut pollution right away, OIT offers a comprehensive portfolio of emerging technology, practices, tools, information, and resources in a variety of application areas, such as, motor systems steam systems, compressed air systems, and combined heat and power systems. Likewise, OIT's Industrial Assessment Centers (IAC), located throughout the U.S., offer energy, waste, and productivity assessments to small and medium-sized manufacturers. Users can take advantage of the abundant resources, such as software, fact sheets, training materials, etc. available from OIT.

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